INTRODUCTION

In addition to oil and natural gas and wind resources, five alternatives deserve assessment as to their potential application off North Carolina:

- Mechanical energy from currents, waves, and tides,
- Thermal energy from the temperature gradients in the stratified ocean, and
- Deep-sea methane hydrates.

Of these latter five resources, the first four are slowly developing in a variety of places around the world, and lessons for North Carolina can be gleaned from that experience. Methane hydrates are recently discovered, nonrenewable and poorly known. Their exploitation seems unlikely in the near future, and will be discussed only briefly.

The ocean can supply four types of renewable marine and hydrokinetic energy: currents, waves, tides, and thermal energy from the temperature gradients in the stratified ocean. The world's oceans cover 71 percent of the earth's surface and represent massive solar-energy collectors and storage systems. The sun's energy differentially heats the atmosphere and the surface waters of the ocean, producing strong thermal gradients within the atmosphere and between the ocean's warm surface and cold deep waters. These temperature differences set the atmosphere and ocean in motion producing a vast store of energy that operates according to the basic principles of thermodynamics.

The ocean's thermal gradients, currents, waves, and tides are all potentially available and could be harnessed from the oceans to generate electricity. However, they are not equally available throughout the ocean, or on land adjacent to the ocean. The type and amount of energy available is totally dependent upon where on earth you are located. Some locations have high wave energy and large tidal amplitudes; other locations have the opposite. Because of the geologic framework of the continental margins, most locations do not have ready access to major ocean currents. The potential use of the ocean thermal gradients is great in the tropics, but non-existent in polar regions.

Assuming all energy sources were equally available, a relative comparison of the importance of each ocean-energy resource can be made. Constans (1979) and Garrison (1996) utilized a relative scale of potential power for the four ocean-energy sources. If the energy potential from waves and tides were assigned relative numbers of 2.5 and 2.7, respectively, then ocean currents have the capability of producing on an order of magnitude more power with a relative scale of 25. Utilizing ocean thermal energy conversion (OTEC), the amount of potential energy production is up to 16,000 times greater. All of the methods for capturing these potential ocean-energy sources are still experimental today. However, there may be a potential for North Carolina in the near future, if an adequate research and technology base can be developed.

Even though there is an incredible flow and storage of solar energy in the world's oceans, that energy is spread out across and through the oceans—the basic problems are in the harvesting of this energy from a hostile and dynamic environment. This leads to a critical question as to what is really available to be recovered from a restricted coastal region (e.g., offshore North Carolina) without disrupting the resulting responses to the Earth's climatic and oceanic system. Consequently, small amounts from any single source may be potentially available if adequate technology can be developed to recover the resource, which presently is a long way from being economically feasible. Thus, the U.S. Department of Energy (Musial, 2008) concluded that "marine (renewable) energy resources are globally significant and should be developed as part of the diverse clean-energy portfolio that will be necessary to reach expected future carbon-reduction targets." However, "no single (renewable) energy source will be able to achieve these reductions independently so many sources must be simultaneously developed."

HYDROKINETIC TECHNOLOGIES

The U.S. Department of Energy (USDOE, 2011a) has a Wind and Water Power Program (http://www1.eere.energy.gov/windandhydro/program_areas.html). Water power is further sub-divided into "Conventional Hydropower" (i.e., the natural flow of water in rivers) and "Marine and Hydrokinetic Technology" (i.e., energy from ocean waves, tides, currents, and ocean thermal gradients). The USDOE (2011b) defines major categories of marine hydrokinetic technology energy sources as presented below (http://www1.eere.energy.gov/windandhydro/hydrokinetic/techTutorial.aspx). All descriptions and figures presented below are taken or modified from that source.